

CHARACTER OF THE OPPOSITION EFFECT AND NEGATIVE POLARIZATION

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Photometric and polarimetric properties at small phase angles have been measured for silicates with controlled surface properties in order to distinguish properties that are associated with first surface reflection from those that are associated with multiple scattering from internal grain boundaries. These data provide insight into the causes and conditions of photometric properties observed at small phase angles for dark bodies of the solar system. Cut surfaces of obsidian and basalt were ground with a 5 μm Al oxide powder and with a 40 μm Al oxide powder to produce two comparable surface textures (called "smooth" and relatively "rough" surfaces). The obsidian was chosen to represent a silicate dielectric with no internal scattering boundaries. A fine-grained basalt was chosen to be a similar silicate but with internal grain boundaries. The reflectance and polarization properties ($15^\circ < \alpha < 90^\circ$) of these 4 relatively dark surfaces and particulate samples of the same material were measured in the RELAB and are discussed in Yon and Pieters (1988, LPSC 18, 581-592). We have extended these measurements to 3° phase angle using the precise laboratory photometer/polarimeter at the Kharkov Astronomical Observatory. The surfaces of all four specially prepared samples exhibit negative polarization at small phase angles. The obsidian characteristics, however, are quite different from those of the basalt. The increase of polarization with phase angle is completely monotonic for both samples of obsidian with the inversion angle (angle of zero polarization) being quite small, 6° for the smooth surface surface and 8° for the rougher surface. There is thus no "polarization minimum" for the obsidian samples. The value at 3° is -0.58% P for the smooth surface and -1.05% P for the rougher surface. The basalt samples, on the other hand, appear to exhibit a polarization minimum plateau and zero polarization occurs at larger angles (9° for the smooth surface and 12° for the rougher surface). Polarization minimum occurs near -0.7% P for the smooth surface and near -0.8% P for the rougher surface. For the photometric analyses, the data for all four surfaces were scaled to the albedo measured at 3° relative to halon. The obsidian samples show no opposition effect whatsoever. Brightness decreases in a distinctly linear fashion with phase angle, the smoother surface decreasing about a factor of two more rapidly. A brightness decrease for the smooth basalt is almost as linear as that observed for the obsidian. The rough basalt surface is the only one to exhibit an opposition effect.

Because the obsidian is free of internal scatterers, light reflected from both the rough and smooth obsidian samples is almost entirely single and multiple Fresnel reflections from surface facets with no body component. Surface structure alone cannot produce an opposition effect. Comparison of the obsidian and basalt results indicates that for an opposition effect to occur, surface texture must be both rough *and* contain internal scattering interfaces. Although the negative polarization observed for the obsidian samples indicates single and multiple reflections are part of negative polarization, the longer inversion angle of the multigrain basalt samples implies internal reflections must also contribute a significant negative polarization component.